

**INDIANA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS MANAGEMENT**

**PROCEDURE FOR EVALUATING VEHICLE DETECTION PERFORMANCE
ITM No. 934-15P**

1.0 SCOPE.

- 1.1** This test procedure covers the methods that a vehicle detector is evaluated in the field, and is placed, maintained, or removed from an approval list.
- 1.2** This ITM may involve hazardous materials, operations, and equipment and may not address all of the safety problems associated with the use of the test method. The user of the ITM is responsible for establishing appropriate safety and health practices and determining the applicability of regulatory limitations prior to use.

2.0 REFERENCES.

2.1 NEMA Standards.

2003 NEMA Standards Publication TS-2 Traffic Signal Controller Assemblies

- 3.0 TERMINOLOGY.** Definitions for terms and abbreviations shall be in accordance with the Department's Standard Specifications, Section 101 and NEMA TS-2 Section 1.

- 4.0 SIGNIFICANCE AND USE.** This ITM is used to evaluate, approve, maintain approval, and remove from the approval listing vehicle detectors which are placed on the Department's List of Approved Traffic Controller Equipment. Each model of vehicle detector will be bench tested and field tested separately.

5.0 APPARATUS.

- 5.1** A fully functional instrumented intersection, with detector data output logging, and live video overlay capabilities.

- 6.0 SAMPLING.** The manufacturer shall furnish, at no cost to the Department, three randomly selected production-run vehicle detectors for field testing.

7.0 PROCEDURE. The Department will evaluate the performance of individual vehicle detectors upon successful completion of all other requirements specific to the vehicle detector being tested.

8.0 BENCH TESTING. The vehicle detector will be bench tested in accordance with the specific ITM procedures for the detector prior to field testing.

9.0 FIELD TESTING.

9.1 For field testing of detection temporal presence and count accuracy of the vehicle detector, the following procedures will be used:

9.1.1 Vehicle detection is required to satisfy two objectives for efficient actuated signal control as follows:

- a) To extend green service to a phase until there is no longer demand or flow rates have reduced to levels for phase termination
- b) To call service to a phase when, and only when, there is demand

9.1.2 Both 9.1.1 requirements are required for optimal intersection efficiency; however, there may be conditions where a fully compliant detector may not be deployable. Consequently, separate performance specifications are defined for as follows:

- a) **Standard Performance Calling/Extension Detector.** Standard Performance Calling/Extension Detectors are used to call a phase that is amber or red and to extend a phase that is green. These detectors are compliant with the NEMA performance specification for induction loop detection. The Department requires induction loop amplifiers and other fully compliant vehicle detection technologies to meet this specification.
- b) **Low Performance Calling/Extension Detector.** Low Performance Calling/Extension Detectors may be used to call service to a phase that is red and to inefficiently extend a phase that is green. These low performance detectors are not compliant with NEMA TS2-2005 specification for loop amplifiers. These low performance detectors provide some benefit over non-actuated control in extending phases, but do not provide the efficiency of a Standard Performance Calling/Extension Detector. Low Performance Calling/Extension Detectors do not provide detection to the precision level required by a NEMA controller to efficiently extend and terminate phases, but may be deployed where Standard Performance Calling/Extension Detectors are not feasible. The Department will consider this lowered standard

- c) of Calling Detector only where a Standard Performance Calling/Extension Detector cannot be reasonably deployed.

9.1.3 Performance Metrics. Detection units shall be evaluated only when the lateral offset of the center of a vehicle (FHWA Class 1-13) is not more than the distance (o) from the center of the lane (Figure 1 and Table 1) and operating at speeds between 0 and 60 mph. Fundamental traffic flow theory and the NEMA TS2-1998 Sections 2.2.2, 3.5.3.1, 6.5.2.17, and 6.5.2.19 demonstrate the importance of 100 millisecond detection resolution for monitoring traffic flow rates for phase termination. Consequently, the following specifications for extension detectors (Table 1) conform to the requirements of 100ms detection resolution.

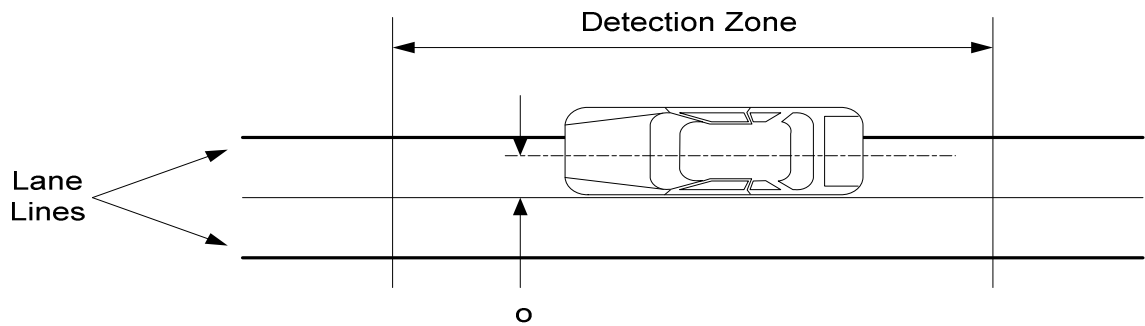


Figure 1: Lateral Detection Zone Boundaries

	Low Performance		Standard Performance	
	During Amber and Red Interval	During Green Interval	During Amber and Red Interval	During Green Interval
Lateral Offset (o)	≤ 3.0 ft	≤ 3.0 ft	≤ 3.0 ft	≤ 3.0 ft
Activation Position, Upstream Tolerance ($A_u - A$)	≤ 6.0 ft	≤ 6.0 ft	≤ 3.0 ft	≤ 3.0 ft
Activation Position, Downstream Tolerance ($A - A_d$)	≤ 6.0 ft	≤ 6.0 ft	≤ 3.0 ft	≤ 3.0 ft
Termination Position, Upstream Tolerance ($T_u - T$)	≤ 6.0 ft	≤ 6.0 ft	≤ 3.0 ft	≤ 3.0 ft
Termination Position, Downstream Tolerance ($T - T_d$)	≤ 6.0 ft	≤ 6.0 ft	≤ 3.0 ft	≤ 3.0 ft
Response Time, Typical ($R_{85\%}$)	≤ 2 sec	≤ 1 sec	≤ 1 sec	≤ 100 ms
Response Time, Maximum ($R_{100\%}$)	≤ 10 sec	≤ 5 sec	≤ 5 sec	≤ 1 sec
False Call Duration (F_d)	≤ 5 sec	≤ 5 sec	≤ 500 ms	≤ 500 ms

Table 1: Parameters for Measuring Detector Performance
(Per respective detection zone)

9.1.4 Detection Zone Operation. The Detection Zone is the region defined by an activation and termination location in a single lane. Figure 2 illustrates the upstream activation location (A) and downstream termination location (T) of the detection zone. The subscripted locations in Figure 2 and Table 1 define the spatial tolerance of these activation and termination points.

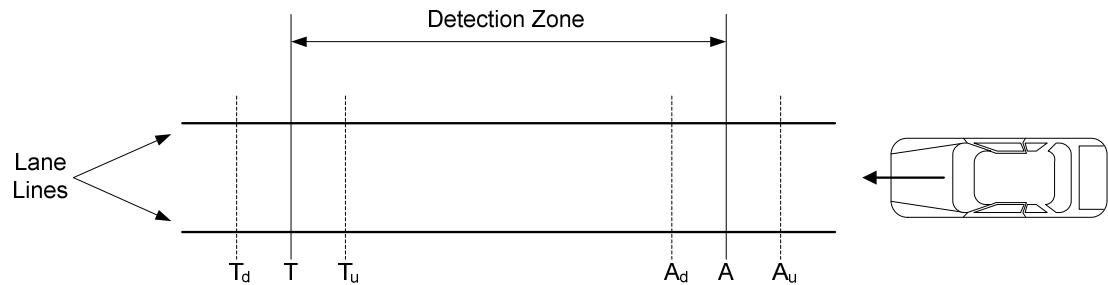


Figure 2: Longitudinal Detection Zone Boundaries

	Low Performance		Standard Performance	
	Performance During Amber and Red Interval	Performance During Green Interval	Performance During Amber and Red Interval	Performance During Green Interval
Number of Missed Calls (N_{mc})	0 /24 h	≤ 10 /24 h	0 /24 h	≤ 10 /24 h
Number of False Calls (N_{fc})	≤ 20 /24 h		≤ 20 /24 h	

Table 2: Acceptance Criteria

- a) The detection device shall call and hold a call as long as any portion of any vehicle is between the upstream point (A_d) and downstream point (T_u)
- b) Failure to detect a vehicle meeting the spatial and timing tolerances listed in Table 1 shall be considered a missed call. Allowable tolerances for Missed Calls (N_{mc}) defined by these criteria are listed in

Table 2. Detection performance outside of these tolerances is grounds for rejection of the device.

- c) The detection device shall not place a call when no portion of a vehicle is between the upstream point (A_u) and downstream point (T_d)

- d) Indication of the presence of a vehicle when no vehicle meets the spatial and timing criteria listed in Table 1 shall be considered a false call. Allowable tolerances for false calls (N_{fc}) defined by these criteria are listed in Table 2. Detection performance outside of these tolerances is grounds for rejection of the device.
- e) Response time at transition points shall be as follows:
 - 1. When transitioning from no-call to call states, the detection device shall indicate a detection no later then ($R_{100\%}$) after the front of a vehicle crosses point (A_d).
 - 2. When transitioning from call to no-call, the detection device shall drop a call no later then ($R_{100\%}$) after the rear of a vehicle crosses point (T_d).

9.1.5 Detector performance specifications shall be as follows:

- a) A vehicle detector shall be considered acceptable for a given lane and application (Calling or Calling/Extension) if:
 - 1. The output response time at the transition points is $\leq R_{85\%}$ for 85% of the call/no-call observations
 - 2. The output response time is $\leq R_{100\%}$ for 100.00% of the call/no-call observations in any 24 h period
 - 3. Not more than (N_{fc}) false calls lasting more then (F_d) are produced in any 24 h period
- b) Calling/Extension Detector performance standards are required to be met for detection devices installed for all lanes of Department intersection, unless prior written approval is obtained from the Highway Support Section of Operations Support Division to use Calling Detector standards for selected lanes.
- c) Environmental conditions shall be as follows:
 - 1. One test period of 24 contiguous hours of operation
 - 2. One test period of 2 contiguous hours of sunny conditions with visible shadows projected a minimum of 6 ft into the adjacent lane(s). Alternatively two different 1 h periods collected at the same sight on at different times is acceptable.

3. One test period of 2 contiguous hours of night time operations with wet pavement and vehicle head lights on. Alternatively two different one hour periods collected at the same sight on at different times is acceptable.

d) Intersection /Approach conditions shall be as follows:

1. The approach shall have a minimum of one left turn lane, two through lanes, and one right or right/through lane.
2. The intersection shall be a in a rural area with no lighting.
3. The left turn movement shall be controlled by a five section protected/permissive head.

9.2 Counting accuracy shall be as follows:

9.2.1 Detectors shall be approved for counting purposes as a separate and independent detection function.

9.2.2 A valid vehicle is defined by the detection zone and vehicle relationships in Table 1.

9.2.3 Counting detectors are required to count valid vehicles with a maximum error rate of ± 10 percent compared to visually ground truth vehicles over a 24 h period and shall not exceed ± 10 percent error for any time interval that includes 50 qualified vehicles.

9.3 When protected/permitted operation is used, detector operations during both the protected and permissive period will be evaluated using the Green Interval Criteria in Table1

10.0 REPORT. A final report will include the notations and findings from the electronic bench test and field testing results and documentation.

11.0 APPROVAL LIST.

11.1 Approval of vehicle detector. The vehicle detector model may be placed on the approval list when the following conditions are met:

11.1.1 The bench and field testing are completed with satisfactory results.

11.1.2 The required documentation is submitted.

11.2 Maintaining Approval.

11.2.1 Once a detection system has been approved; each time any change in the firmware is made the vendor shall provide the Department with the following:

- a)** Induction Loop Amplifiers. The vendor shall furnish the Department with test results from a calibrated ATSI ALSA-1250 or equivalent loop system analyzer to verify NEMA compliance. The vendor shall notify the Department prior to shipment of amplifiers containing firmware updates.
- b)** Non Loop Based Systems. The vendor shall furnish the Department with a DVD video recording of the detector operation, demonstrating that the detector continues to meet the original acceptance criteria listed in Table 2, with the detector and phase status of each lane overlaid on the video, and including the following conditions:
 - 1.** Environmental Conditions:
 - a. One clip of 24 contiguous hours of operation.
 - b. One clip of 2 contiguous hours of sunny conditions with visible shadows projected a minimum of 6 ft into the adjacent lane(s). Alternatively two different 1 h periods collected at the same sight on at different times is acceptable.
 - c. One clip of 2 contiguous hours of night time operations with wet pavement and vehicle head lights on. Alternatively two different 1 h periods collected at the same sight on at different times is acceptable.
 - 2.** Intersection /Approach Conditions:
 - a. The approach shall have a minimum of 1 left turn lane, 2 through lanes, and 1 right or right/through lane.
 - b. The intersection shall be a in a rural area with no lighting.
 - c. The left turn movement shall be controlled by a five section protected/permissive head.

All video on the DVD shall be recorded at vendor recommended maximum setback of detection zones from the video camera. A shop drawing showing camera elevation, detection zone setback, detection zone sizes shall accompany the DVD along with a letter certifying that the DVD was recorded using the new firmware version and has been verified to meet the above standards.

11.2.2 If the manufacturer makes any changes to an approved model to correct a non-NEMA compliancy or other safety issue, the Department shall be notified immediately. The manufacturer shall correct all existing equipment purchased by the Department either directly, by contract, or through agreement prior to the change being incorporated at the manufacturer's production level.

11.2.3 A design change to an approved model shall require a submittal of documented changes. At the discretion of the Department, resubmission of the model for testing and evaluation may be required. Permanent addition or removals of component parts or wires, printed circuit board modifications, or revisions to memory or processor software, are examples of items that are considered to be design changes.

11.3 Removal from Approval List. The vehicle detector will be removed from an approval list for, but not limited to, the following reasons:

11.3.1 Changes in the vehicle detector components or production process that fail testing and/or evaluation

11.3.2 If three consecutive years elapse without furnishing the vehicle detector

11.3.3 Performance of the vehicle detector no longer meets the intended purpose

11.3.4 Recurring similar product failures indicative of a manufacturer's defect